NASA Institute for Advanced Concepts

Summary of Responses

to the

REQUEST FOR INFORMATION

Human / Robotic Exploration of the Solar System

presented by
Dr. Robert A. Cassanova
Director, **NASA Institute for Advanced Concepts**

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Wyn Wachhorst
The Dream of Spaceflight

It is at its frontiers that a species experiences the most perturbing stress. The urge to explore, the quest of the part for the whole, has been the primary force in evolution since the first water creatures began to reconnoiter the land. We humans see this impulse as the drive to self-transcendence, the unfolding of self-awareness…

Living systems cannot remain static; they evolve or decline. They explore or expire. The inner experience of this imperative is curiosity and awe. The sense of wonder—the need to find our place in the whole—is not only the genesis of personal growth but the very mechanism of evolution, driving us to become more than we are. Exploration, evolution, and self-transcendence are but different perspectives on the same process.

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Wyn Wachhorst, The Dream of Spaceflight

The frontier, like the world of the child, is a place of wonder explored in the act of play. Work is self-maintenance; play is self-transcendence, probing the larger context, seeking the higher order…

Joseph Campbell has observed that in countless myths from all parts of the world the quest for fire occurred not because anyone knew what the practical uses of fire would be, but because it was fascinating. Those same myths credit the capture of fire with setting man apart from the beasts, for it was the earliest sign of that willingness to pursue fascination at great risk that has been the signature of our species. Man requires these fascinations, said the poet Robinson Jeffers, as "visions that fool him out of his limits."

Like the capture of fire, the longing for space-flight is rooted less in means than in meaning itself.

Site Selection and Deployment Scenarios
For Servicing of Deep-Space Observatories
HARVEY J. WILLENBERG
Boeing Human Spaceflight and Exploration

- **Summary of key characteristics of future observatories designed to operate at the Sun-Earth Lagrange point**
- **Defines range of servicing missions with teleoperated robots and autonomous robots**
- **Trade study of alternative servicing sites: ISS and other LEO locations, lunar orbit and Earth-Sun L2**

A Taxonomy of Potential Cooperative
Human/Robotic Roles in Extravehicular Operations
DAVID L. AKIN
University of Maryland – Space Systems Lab

Artificial Gravity

LAURANCE YOUNG and **HEIKO HECHT**

Massachusetts Institute of Technology

- **Artificial Gravity is the single most promising Countermeasure against space adaptation syndrome**
- **Long-term human space missions will most likely have a short-radius centrifuge (combined with exercise equipment) on board**
- **Preliminary ground-based studies show great promise regarding the feasibility of short-radius centrifugation**
- **Further ground-based research as well as flight experiments with a human centrifuge are indispensable**

Open Future Functionality

DAN FISCUS

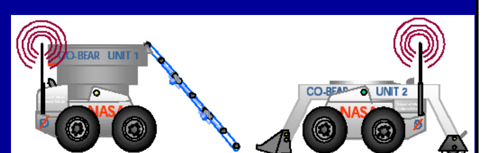
University of Maryland – Appalachian Lab

- **How these concepts would impact synergistic operation of humans and robots**
- **Enhanced science that would be enabled**

Robotic Outposts

WENDELL H. CHUN

Lockheed Martin Space Systems Company



Traverse Planning for Mars Surface Exploration

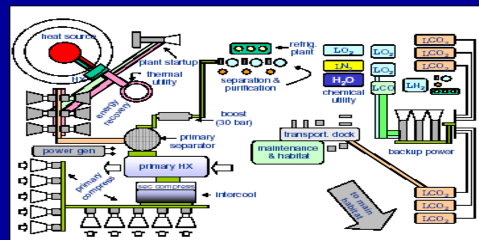
CHRISTOPHER CARR and **DAVA NEWMAN**

MIT Department of Aeronautics & Astronautics

Making Oxygen on Mars – The Mars Atmosphere Resource Recovery System

CHRISTOPHER ENGLAND

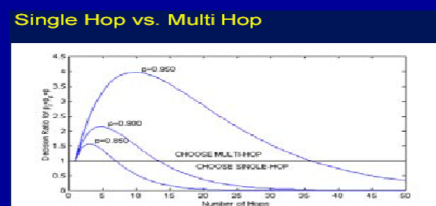
Engineering Research Group



Distributed Architectures for Mars Surface Exploration

CHRISTOPHER CARR and **DAVA NEWMAN**

MIT Department of Aeronautics and Astronautics



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Advanced EVA Roadmaps and Requirements

RICHARD K. FULLERTON

NASA Johnson Space Center

Remote Planetary Mechanical Mirroring using Controlled Stiffness and Actuators (MEMICA)

CONSTANTINOS MAVROIDIS

Rutgers University

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Metamorphic Robotic Systems for Space Exploration

WEI-MIN SHEN
University of Southern California
SILVANO COLOMBANO
NASA Ames Research Center

Titan Astroplane: Feasibility Considerations for Unmanned Aerial Vehicle Flight on Saturn's Moon

RYAN SCHAEFER and **MARSHALL BRENIZER**
Androit Systems, Inc.

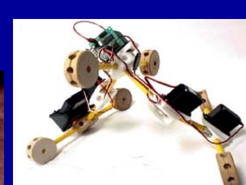
Design and Analysis of Trunk and Tentacle Robots

IAN D. WALKER
Clemson University

8 degree of freedom spatial "elephant's" trunk

Self-Designing Machines

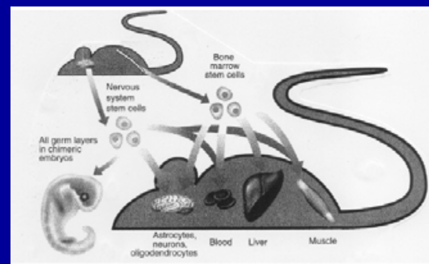
HOD LIPSON
Cornell University



Human/Robotic Hematopoietic Stem Cell Therapy and Gene Therapy for Exploration of the Solar System

SEIGO OHI

Howard University and Hospital



Cybernetic Integration of Human-Robot Systems

THOMAS J. SMITH

ROBERT A. HEMMING

University of Connecticut

- **Human-robot interaction modeled and characterized as a social cybernetic process**
- **Human participants are allocated primary feedforward control, and computer-robot participants primary feedback control.**

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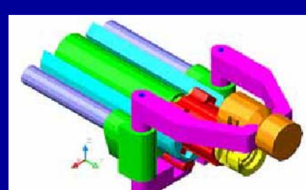
Advanced Revolutionary Concepts for On-orbit Assembly of Large Structures

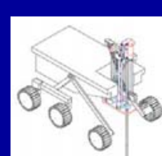
EDWARD J. FRIEDMAN

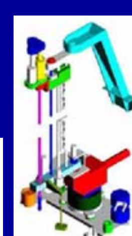
The Boeing Company

- **Integrated modeling of optics, structures and control**
- **Humans at L2 and beyond**
- **Structural concepts**
- **Precision low mass structural joints**
- **Deployment versus assembly in space**
- **Active versus passive control**

Engineering The Future
SUPARNA MUKHERJEE and
CHRIS CHAPMAN
Honeybee Robotics, Ltd.







Open Future Functionality

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University of Maryland – Appalachian Lab

- **How these concepts would impact synergistic operation of humans and robots**
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The Role of Robotics in Human Mars Surface Exploration

MICHAEL SIMS

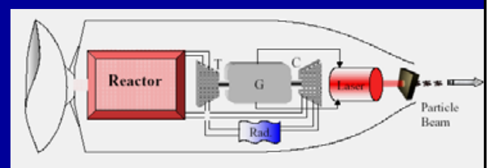
NASA Ames Research Center

- **A classification of needed planetary surface robots**
- **A program to understand needs**
- **Makes a case for an ongoing, orderly process that builds on strengths of the past and stays focused on clear goals**

A Near-Term Propulsion System for Human/Robotic Exploration of the Solar System

TERRY KAMMASH

University of Michigan



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The Space Elevator

BRAD EDWARDS

Eureka Scientific

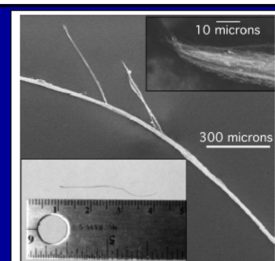
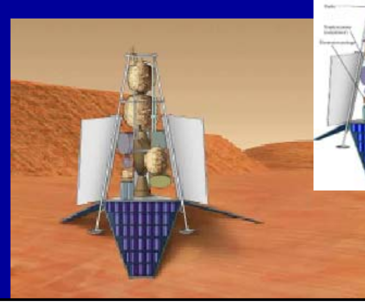


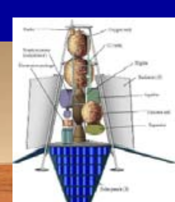
Figure 1: A carbon nanotube bundle. Carbon nanotubes produced by the system had measured tensile strengths of 22 GPa.

In-Situ-Refueled Rocket "Hopper" for Mars Exploration

GEOFFREY LANDIS and **DIANE LINNE**

NASA John Glenn Research Center





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NIAC Phase I Call for Proposals, CP 01-02

Can be downloaded from NIAC website: http://www.niac.usra.edu

Proposals Due: February 11, 2002

Technical Proposal: 12 pages, 300K, submitted electronically only

$75K Grant

Performance Period: up to six months

Phase I recipients become eligible to submit Phase II proposal

Visionary Challenges Listed in CP 01-02

- Fulfill the human desire to understand our place in the universe.
- Seek knowledge to understand how we evolved and what is our destiny.
- Search for life in the universe and understand cosmological phenomena.

- Pursue the fascination of space and satisfy the human drive for exploration of the vastness of space, often at great risk.
- Make possible the safe, affordable and effective exploration, development and self-reliant habitation of our solar system – and eventually space beyond our solar system – by humans and their agents.
- Mediate the effects of the space environment, such as microgravity and radiation, on humans and other living things,

- Provide seamlessly integrated, safe, reliable, fast and efficient transportation network from the Earth's surface to distant locations in space as well as portal to portal on the Earth's surface.

- Understand the influence on the Earth system of the actions of mankind, the natural cyclic phenomena in the Earth's system and the interaction of the Sun-Earth system.
- Create tools and techniques to access, visualize and interpret data and model findings.
- Predict the future evolution of the Earth system and its relationship to natural phenomena and human activity, and validate this predictive capability.